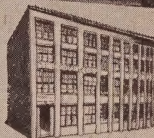


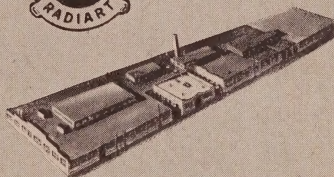
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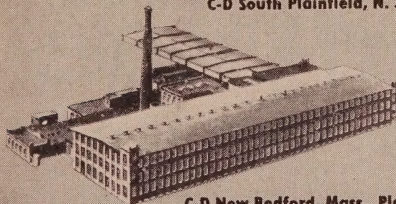


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FEBRUARY, 1953

No. 2

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A HIGH-SELECTIVITY PASS-REJECT AMPLIFIER

In the communications and electronic fields, the need often arises for a highly-selective amplifier which will either pass or reject a given frequency while leaving adjacent frequencies, at and beyond one octave on each side of the frequency of interest, relatively unaltered in the case of the reject function, and suppressing these frequencies to a point of insignificance in the case of the pass function. A number of such amplifiers have been described from time to time in radio articles. Most of them employ resistance-capacitance selective circuits to obtain frequency sensitivity.

Most of the amplifiers described previously have not afforded sufficient selectivity for many purposes unless considerable complication was introduced into the circuits. This article describes a simple, 2-tube (4-stage) single-frequency amplifier which will pass or reject 1000 cycles with high selectivity. Either the pass or reject function may be selected at will by means of a

double-pole, double-throw switch. In the pass condition, a 1000-cycle signal is transmitted with approximately 60 db attenuation of all signals up to 500 cycles and from 2000 cycles outward. In the reject condition, a 1000-cycle signal is attenuated more than 100 db, while signals up to 500 cycles and from 2000 cycles out are not affected appreciably.

When used as a filter in any equipment, the amplifier has no insertion loss, in fact it can provide gain. Its input impedance is high, as is also its output impedance. By a suitable selection of only four components, the unit may be adapted to frequencies other than 1000 cycles.

Applications of the selective amplifier are self-evident. They include use as a null-detector amplifier with a. c. bridges, selector or rejector in c. w. telegraph reception, audio generator filter, selective element in audio wave analysis or distortion measurement,

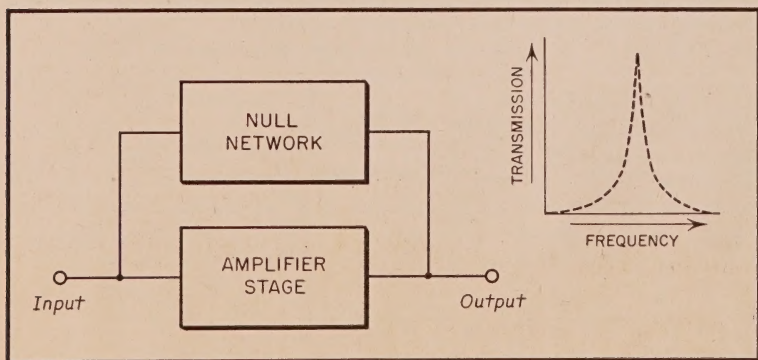


Fig. 1. Feedback amplifier with bandpass characteristic.

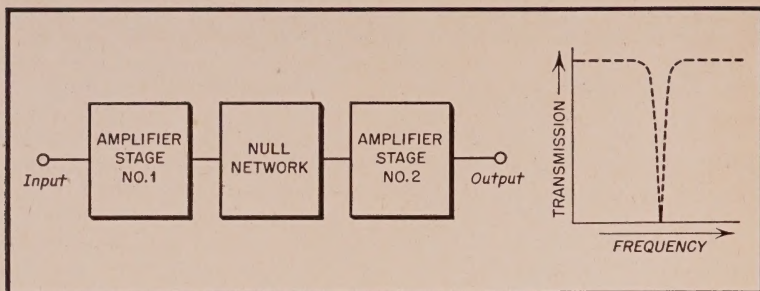


Fig. 2. Feedback amplifier with band-rejection characteristic.

selective amplifier for signalling systems, etc.

The unit is small in size and inexpensive. It can be assembled completely within a few hours. Its power requirements are modest; 6 milliamperes at 300 volts d. c. and 0.6 ampere at 6.3 volts a. c. or d. c.; and power often can be drawn from the equipment, such as a radio receiver, in conjunction with which the selective amplifier is operated.

Operating Principle

Operation and development of the amplifier is expressed by the func-

tional block diagrams, Figures 1 to 3 inclusive. The selectivity of the unit is achieved by means of negative feedback.

As shown in Figure 1, a bandpass characteristic may be imparted to an amplifier by providing negative feedback, through a frequency-selective null network, around a single amplifier stage. Operation is based upon the fact that the null network is tuned to remove one frequency. This frequency accordingly is not fed back to the amplifier input. If the feedback voltage is high enough, it will cancel the amplifier gain, preventing trans-

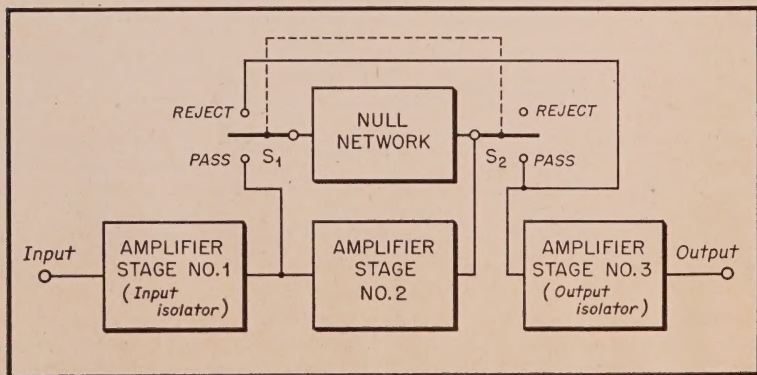


Fig. 3. Arrangement of complete amplifier for "Pass" or "reject" operation.

mission of a signal. There will be no feedback and thus no gain cancellation at the null frequency of the network, however, and the amplifier will transmit signals on that frequency.

The shape of the transmission curve is shown in Figure 1. The sharpness of the curve depends both upon the magnitude of the feedback voltage and the sharpness of response of the null circuit. The higher the Q of this circuit, the sharper will be the transmission curve and also the greater the ratio between its maximum and minimum transmission amplitudes.

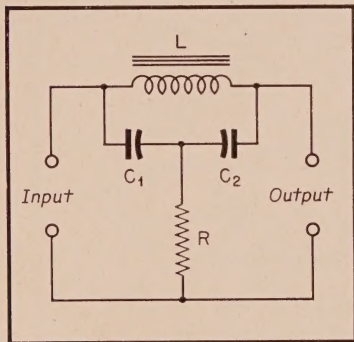


Fig. 4. Bridged-T null network employed in the amplifier feedback loops.

The most efficient band-rejection action is afforded by a high- Q null network inserted between two successive amplifier stages. This arrangement is illustrated by Figure 2. In this setup, the input amplifier provides high-impedance input and isolation. The output amplifier provides amplification (to overcome the possible insertion loss of the null network) and isolation of the network from the output load. The shape of the rejection curve is illustrated in Figure 2. The higher the Q of the null network,

the sharper will be the curve, the lower the dip, and the flatter the transmission to one octave on each side of the rejection dip.

The functions of both bandpass and band rejection may be obtained at will if the null network is arranged in the amplifier circuit to provide the configurations in Figures 1 and 2. A satisfactory switching arrangement is shown in Figure 3. When the d. p. d. t switch, S_1 - S_2 , is in its PASS position, the null network is connected between the output and input of the center amplifier stage (AMPLIFIER STAGE No. 2). The arrangement thus is identical with Figure 1. Amplifier Stage No. 1 provides high input impedance and input isolation. Amplifier Stage No. 3 provides output isolation. The entire setup provides gain which precludes any insertion loss, such as would be exhibited by a conventional non-electronic filter.

When switch S_1 - S_2 is in its REJECT position, the null network is interposed between Amplifier Stage No. 2 and Amplifier Stage No. 3. The network thus is operated at the higher signal level made possible by the voltage amplification of the first two stages. Amplifier Stage No. 3 functions as an output isolator.

It has been mentioned already that best performance is obtained with both bandpass and band rejection arrangements when the null network has high Q . This discourages the use of R-C circuits which otherwise are desirable because of their simplicity and compactness. Figure 4 shows the bridged-T type of null network which is recommended. L is a high- Q inductor, while C_1 and C_2 are high-grade mica capacitors. The Q of a well-designed

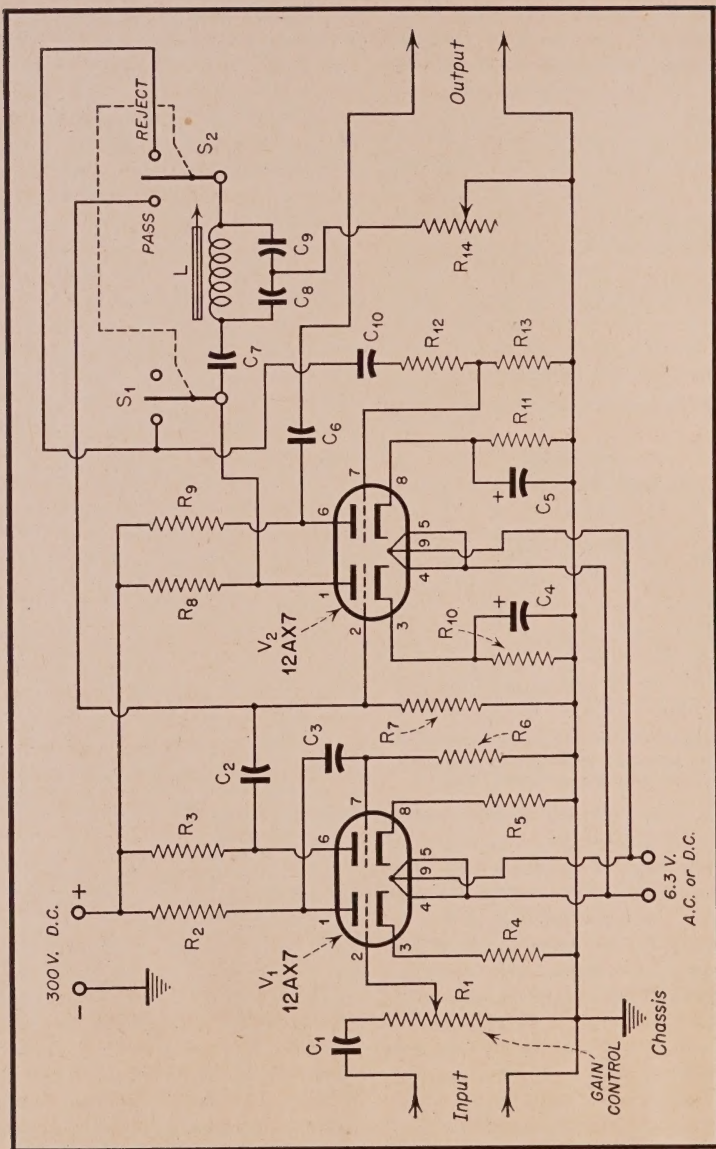


Fig. 5. Complete circuit of the combined pass-reject amplifier.

bridged-T network for the audio frequencies is such that frequencies at and outside of one octave on each side of the null frequency are virtually unattenuated.

Capacitances C_1 and C_2 are made identical in value. The null frequency of the network is approximately the resonant frequency of L and $\frac{1}{2}C_1$. Resistance R is an important and necessary component in the circuit. It is equal approximately to one-fourth of the parallel resonant impedance of the circuit. Sharpest null occurs when R is adjusted properly.

If capacitances C_1 and C_2 are exactly equal, the circuit is symmetrical and either pair of terminals (left or right) may be used for the input or output of the bridged-T network. Unlike standard 4-arm bridge circuits which often are employed as null networks, T-networks offer the advantage of a ground return that is common also to generator (input) and detector (output). This is a desirable feature, since it eliminates the evils of floating circuits.

Complete Circuit

Figure 5 shows the complete circuit schematic of the combination selective amplifier.

The four required amplifier stages are provided by the two 12AX7 dual triode tubes, V_1 and V_2 . These stages are operated in cascade. The first two stages have unbypassed cathode resistors which introduce current degeneration for the improvement of frequency response and reduction of distortion.

The bridged-T null network is comprised by choke L , capacitors C_3 and C_6 , and rheostat R_{14} . L is a miniature

tuneable 5-henry audio choke (U. T. C. Type VI-C15). R_{14} is a 500,000-ohm rheostat. With $C_3 = C_6 = 0.01$ ufd., the null frequency of the network is 1000 cycles. With the same choke, other operating frequencies may be secured by changing the capacitor values but keeping each equal to the other at all times.

The double-pole, double-throw switch S_1 - S_2 , shifts the null network in the amplifier circuit to provide pass or reject characteristics. When the switch is in its PASS position, the network is connected between the plate and grid of the first triode of V_2 . This provides the arrangement shown in the block diagram, Figure 1. The two triodes of V_1 serve as input amplifiers, and the second triode of V_2 as an output isolation amplifier.

When the switch is in its REJECT position, the null network is connected between the plate of the first triode of V_2 and the grid of the second triode of V_2 . This provides the arrangement shown in the block diagram, Figure 2. The first three input amplifier stages then are ahead of the null network, and the last amplifier stage follows it.

The amplifier requires 300 volts d. c. at approximately 6 milliamperes for the tube plates, and 6.3 volts a. c. or d. c. at 0.6 ampere for the tube heaters. Both voltages often may be extracted from the power supply of the radio receiver or other instrument with which the amplifier is used. The tube heaters are connected (at the tube sockets), as shown in Figure 5, for 6.3-volt operation. For hum reduction, one heater terminal must be grounded to the amplifier chassis, unless (when taking power from another

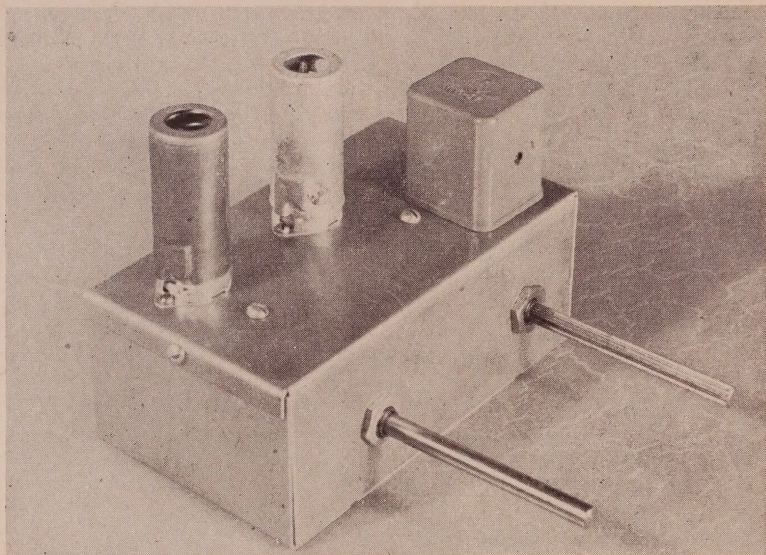


Fig. 6. Miniature version of the selective pass-reject amplifier.

instrument) the filament line already is grounded in that instrument.

Mechanical Construction

The comparative simplicity of the amplifier allows considerable latitude in the mechanical arrangement of an individual model.

The unit shown in Figure 6 was made small, completely shielded, and compact for mounting on a small existing power supply chassis. The entire setup was planned originally as a pass-reject filter for a communications receiver rack. The receiver beat oscillator is adjusted for a 1000-cycle beat with a signal of interest. In the PASS position of the function switch, the amplifier transmits this signal to headphones or loudspeaker, while effectively rejecting all others. In the REJECT condition, the amplifier elimi-

nates this one signal while allowing all others to pass unaltered.

The amplifier as shown in Figure 6 is built into an aluminum radio-chassis box $5\frac{1}{4}$ " long, 3" wide, and 2" high. The smallest available components are used throughout in the construction. A still smaller version of the amplifier might be built for inclusion in other instruments in which space is limited.

The tuning screw may be seen on the front of the case of the small choke. The two protruding shafts are the input volume (gain) control on the left, and the rotary function switch on the right.

It is advisable to shield the entire amplifier, each tube individually, as seen in Figure 6. The input lead also must be shielded, although the output leads need not be.

To prevent hum, filament wiring should be twisted tightly and kept close against the chassis. It is a good idea to install the filament wiring first and then to proceed with the rest of the wiring.

Since rheostat R_{14} requires adjustment only during the initial calibration of the amplifier, when tubes are changed, or at infrequent intervals to compensate for aging tubes and components, it needs no tuning knob. It should be provided with a slotted shaft for screwdriver adjustment. In the unit shown in Figure 6, R_{14} is mounted on the rear lip of the chassis.

Initial Adjustment

After the wiring has been checked and found correct, the amplifier may be adjusted with the aid of a sine-wave audio oscillator.

(1) Connect the audio oscillator to the amplifier input terminals. (2) Connect a high-impedance a. c. vacuum-tube voltmeter to the amplifier output terminals. (3) Connect the amplifier to a power supply furnishing 300 volts d. c. and 6.3 volts a. c. or d. c. (4) Set the amplifier gain control, R_1 , to its minimum-gain position. (5) Set the amplifier function switch, S_1 - S_2 , to its PASS position. (6) Switch-on the oscillator, amplifier, and v. t. voltmeter, and allow a 10-minute warm-up period. (7) Set the oscillator to 1000 cycles and advance the oscillator output control a small amount. (8) Set the amplifier gain control, R_1 , to about $\frac{1}{4}$ maximum. (9) Adjust the tuning screw of choke L for a peak deflection of the v. t. voltmeter. (10) Adjust rheostat R_{14} for a higher deflection of the voltmeter. (11) Readjust the tuning

screw in choke L. (12) Work back and forth between L and R_{14} until the highest meter deflection is obtained. (13) Detune the oscillator successively to 500 cycles and to 2000 cycles, noting the drop in meter reading. (14) With the oscillator set to 100 cycles, set switch S_1 - S_2 to its REJECT position. (15) Now, tune the oscillator through its range, noting that the v. t. voltmeter deflection drops sharply and dips deeply as the frequency passes through 1000 cycles.

PARTS LIST FOR FIGURE 5

- C_1 —0.1 ufd. 400 v. tubular (C-D PTE 4S1)
- C_2 , C_3 , C_6 , C_7 , C_{10} —0.05 ufd. 400 v. tubular (C-D PTE 4S5)
- C_4 , C_5 —25 ufd. 50 d. c. w. v. midget tubular electrolytic (C-D BR255A)
- C_8 , C_9 —0.01 ufd. mica (C-D 1D3S1)
- L—Adjustable 5-henry choke (U. T. C. Type VI-C15)
- R_1 —500,000-ohm midget potentiometer
- R_2 —100,000 ohms 1 watt
- R_3 —100,000 ohms 1 watt
- R_4 —2000 ohms 1 watt
- R_5 —2000 ohms 1 watt
- R_6 —2.7 megohms $\frac{1}{2}$ watt
- R_7 —1 megohm $\frac{1}{2}$ watt
- R_8 —100,000 ohms 1 watt
- R_9 —100,000 ohms 1 watt
- R_{10} —1200 ohms 1 watt
- R_{11} —1200 ohms 1 watt
- R_{12} —100,000 ohms $\frac{1}{2}$ watt
- R_{13} —10,000 ohms $\frac{1}{2}$ watt
- R_{14} —500,000-ohm midget potentiometer
- S_1 - S_2 —Double-pole, double-throw rotary switch
- V_1 , V_2 —12AX7 tubes

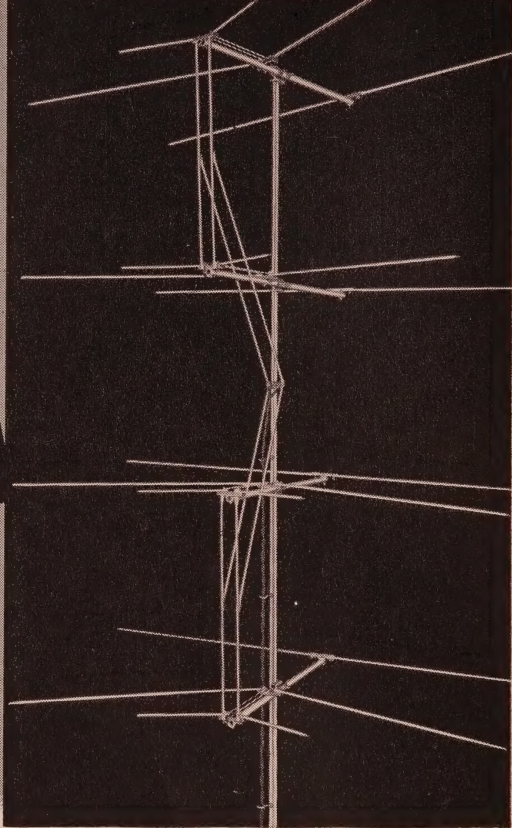
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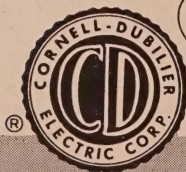
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FOR SALE — Complete Link 30mc police car radio system in good working condition with cables, control head and instruction manual. Needs only mike, xtal and antenna to put on ham band. Stephen V Marsh, 3908 W. Roscoe, Chicago 18, Ill.

TRADE — Have Weston Master II Exp. Meter, new V.M., 920 3-speed record changer, 5 vol. Coyne App. Prac. Rdo., Sams vol. 1, 2, 4, Riders vol. 12, apt.-size washer. Want proj. T.V., binoculars, or what? Lui-Lektrik, Woodward, Iowa.

SALE OR TRADE — Heathkit SG6 signal generator calibrated. Works perfect. Instructions included \$20. or trade for Heathkit 6 volt battery eliminator. Donald Walker, 125 Guess St., Greenville, S. C.

FOR SALE — 2 meter rig 522 xmitter and receiver with power supply in cabinet, all circuits metered, Al cond. S meter \$55 FOB. Center TV, 867 Broad, Central Falls, R. I.

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SWAP — Radio-TV tubes for test equipment, tape recorder, com. receiver or what have you. S. Consalvo, 2507 Southern Ave., SE, Washington 20, D. C.

FOR SALE — Hickok mutual conductance tube checker, model 560 SPL., \$22.50. Has noise, gas, life, and short tests. Good condition. In carrying case. H. D. Wiecek, 205 Idlewylde, Louisville 6, Kentucky.

WANTED — Hallicrafter rec. in good or new cond. Must be below wholesale price. Myron Rosenthal, 453 Hopkinson Ave., Brooklyn 12, N. Y.

FOR SALE — Power xformers, late model Dumont TV, perfect, \$5 each. Express extra. Horowitz, 1775 E. 17th St., Brooklyn 29, N. Y.

WANTED — Portable tape recorder. Prefer type which records half of tape. Will trade test equipment, Waterman S10A complete scope, Simpson 260, Simpson pocket VOM, Supreme tube tester, amateur transmitting equipment. R. N. Eubank, 1227 Windsor Ave., Richmond 27, Virginia.

TRADE — 1892 Blickendorff typewriter for a good Vibroplex or equal bug. G. Samkofsky, 527 Bedford Ave., Brooklyn 11, N. Y.

WANTED — Electric motor device to wind spring driven phonograph; also good 35mm reflex camera and projector. Have Westinghouse industrial analyzer VAO-8PF and other instruments. Arthur St. Arnaud, 5019 Indianapolis Blvd., East Chicago, Ind.

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FOR SALE — Radio parts and old test equipment. Cheap. To some lad who is really interested in the game. FOB here. Ivan L. Crowe, 2708 Westbrook Dr., Franklin Park, Ill.

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FOR SALE — Hallicrafters S-38B in good condition, \$38 or best offer. Bill Messina, 558 East Fifth St., Boston 27, Mass.

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WANTED — Schematic circuit diagram of National 101 X receiver. Will pay cash. Eagen Smith, 2020 4th St, Madison, Ill.

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FOR SALE — Precision tube and set tester 920P, \$45. NRI all wave tester, \$25. This is multimeter and signal generator, 130kc to 28 meg. Needs batteries. T. H. Clark, 2732 Harford Rd., Baltimore 18, Md.

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FOR SALE — Eico model 950-A capacitor and resistor checker. Completely assembled, never used. Original Eico guarantee and operation manual included, \$23. N. Liemberger, 193 Windermere Blvd., Buffalo 23, N. Y.

WANTED — TV and radio serviceman with experience and own tools. Permanent job, no floaters wanted or shortcut artist. Give salary expected, and experience in first letter. Butler Electric Co., Box 431, Eustis, Fla.

FOR SALE — 21" Vidio console TV with doors. Has new picture tube. Beautiful cabinet. Sacrifice, \$140, or what have you? Philip R. Li Calzi, Greenwich, N. J.

SELL OR SWAP — New complete 1951 Ford custom auto radio, \$50. RCA police mobile 30 watts AM transmitter complete 10-20 meters, two units, \$60. Want movie camera, projector, wire recorder or ham gear. Frank Guetter, 11828 S. Sangamon, Chicago, Ill.

SELL OR SWAP — Webster three post intermix 78 RPM record changer in good condition, automatic shut-off. Best offer or what have you? M. Corn, 53 Frances St., Shrewsbury, N. J.

SELL OR TRADE — Webster record changer model 55-1A, \$10. Bogan TV booster, model BB 1, \$21, or will trade for 16mm sound features. G. D. Griffin, 2101 Barclay, Oklahoma City 14, Okla.

FOR SALE — Radio and electric shop, 2-story bldg., with 1-story addition, completely stocked, household furnishings included. Wonderful opportunity. Jackson Radio, 209 1/2 W. 2nd. Madrid, Iowa.

WANTED — Tech. manual for BC224D receiver. Will pay any reasonable price. George W. Waters, 134 W. Frambes Ave., Columbus, Ohio.

WANTED — Guitar pickup. State make, condition, and lowest price. Emanuel Weiner, 2476 W. 77th Ave., Philadelphia 38, Pa.

FOR SALE — Tape recorder, Brush BK401, in excellent condition; will include one empty reel and one brand new roll, 1200', of Scotch plastic recording tape, \$85, freight paid. Al Dresner, 197 Clinton St., Brooklyn 1, N. Y.

SALE OR TRADE — Never used "Sparx" 905A signal tracer for \$35. Riders manuals 1 to 9 and 4 folders of Sams, all for \$55. Want small radios or police FM. No junk. Dick Miller, 1934 E. Broadway, Muskegon, Mich.

TRADE — Microscope, portable typewriter, Elgin wrist watch, medical diathermy, for VTVM, Eico, service, inst., etc. R. Denmark, 1475 Walton Ave., New York 52, N. Y.

WANTED — Auto radio 1949 Ford 2-door DeLuxe. Have camera, sig. gen. What have you in auto access? P. Kacoure, 148-09 Jamaica Ave., Jamaica 35, N. Y.

FOR SALE — W. E. 4A reproducer with matching transformer; BC-412-B oscilloscope (non-converted) and Brush BK-414 tape recorder. Local deal only, will not ship. N. I. Wolk, 1411 Avenue N, Brooklyn 30, N. Y.

WANTED — Norelco projection unit complete for use with RCA type 630 TV chassis. State condition fully. Palomar Equipment Co., 4254 Niagara Ave., San Diego 7, Calif.

FOR SALE — Eico, 950A, RC bridge and RCH comparator. Wired. Slightly used. \$15 FOB. C. Zieg, 942 30th St., San Pedro, Calif.

FOR SALE — Supreme 504-B, excellent condition, \$55. Robson-Burgess VOM, good condition, \$12. Will ship prepaid. Manuel J. Smith, 1205 Lamanché St., New Orleans 17, La.

FOR SALE — Precision RF 10 vacuum tube probe complete with 9002 tube and instructions. New used. \$6 prepaid. R. A. Dressler, 355 Front St., Millersburg, Pa.

FOR SALE — Emerson midget radio, model AU-190, complete, 5 tubes, AC-DC, excellent condition, \$7.50 C.O.D. 3-tube Vision telebooster, model TV2, less tubes and cabinet, \$7.50 prepaid. Victor Kozma, 1665 Stadium Ave., New York 61, N. Y.

SELL OR SWAP — Electronic photo-flash sets, parts, kits, and HV equipment. Want antiques, paintings, camera equipment. Benedict Sales, Bath, Pa.

FOR SALE — Heath TS-2 sweep gen. \$35; BC-412 radar scope, \$45; Feiler VTVM, \$18; Fada FM tuner, \$17; all in good condition. J. Mrochak, R. 4, Lapeer, Mich.

FOR SALE — New Meissner analyst complete with tubes, test probes, and instruction book, \$60. Berman Distributing Co., 1188 Broadway, Brooklyn 21, New York.

FOR SALE — IRE Proceedings, 1939 to 1952. J. Schindler, 38 Walnut Park, Boston 19, Mass.

WANTED — Tubes 1SA6, 1SB6, 3A8. State condition, will trade or purchase. T. Rem, 9601 St. Cyril, Detroit 13, Mich.

WANTED — Riders Vol. 16 on up; Eico or Heathkit scope in good condition. Local seller preferred. Irv's Electric Shop, Ingalls, Kan.

FOR SALE — Established radio repair shop, complete with testing equipment, tubes, volume controls, resistors, coils, condensers, speakers, cabinets, etc. John Corrado, 85 Liberty St., Newburgh, N. Y.

FOR SALE — Sam's Photofacts, 1 to 13, \$10; Simpson volt-ohm-ammeter, model 260, \$22. Hy Levine, 223 Lynch St., Brooklyn, N. Y.

FOR SALE — National SW-54 receiver, like new, \$37; and 6V6 ten watt xmttr with coils and tubes, \$10 J. K. Udseth, Summit, S. Dak.

WANTED — A black or ivory cabinet for a Truetone table radio model D731. Irving Horowitz, 22B Packard Court, Niagara Falls, N. Y.

WANTED — Gardiner automatic tape code sender with code tape lessons, or similar equipment. Also want Philco 7071 AM-FM sweep generator. R. W. Daniels, 1418 Division St., Hopkins, Minn.

FOR SALE — Hallicrafter S-40B receiver. Best cash offer takes it. Stanley J. Hlastava, 42 Canal St., Jewett City, Conn.

WANTED — Rider manuals 19 and/or 21. State lowest price. Elton Hoornstra, 305 Ann St., Sault Ste. Marie, Mich.

FOR SALE — Riders Manuals Vol. 1-11 inclusive with index. Excellent condition. Must sell lot. Best cash offer accepted. Joseph Masone, 33 Barrett Avenue, Stamford, Conn.

WANTED — High voltage oil and mica capacitors, new or new surplus only, any quantity, state price. Standard Radio-Electrical Products, 51 W. 3rd St., New York 12, N. Y.



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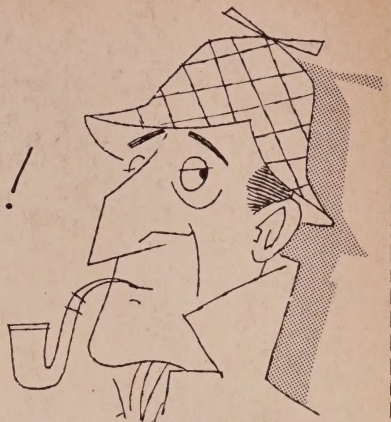
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